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Geophysical Applications for RCRA/CERCLA Investigations

Task 5 Plume Delineation of Landfill Drainage at the Rocky Flats Plant

Draft Report

U.S. Department of Energy
Rocky Flats Plant
Golden, Colorado

8 May 1991

EG&G Rocky Flats, Incorporated

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GEOPHYSICAL APPLICATIONS
FOR
RCRA/CERCLA INVESTIGATIONS
TASK 5

Plume Delineation of Landfill Drainage
Rocky Flats Plant

DRAFT REPORT

May 1991

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Prepared for:

EG&G ROCKY FLATS, INC.
CONTRACT NO. ASC 37245PB

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EXECUTIVE SUMMARY

The Task 5 Rocky Flats EM Survey was performed to determine the effectiveness of the EM geophysical method for lateral subsurface mapping of highly concentrated TDS plumes, and to determine the primary source(s) of the TDS plume(s) The EM method was chosen because of its cost effectiveness and high spatial resolution capabilities

The results of the EM modeling and field investigation indicate that it is possible to define a relationship between the TDS concentration and the pore water conductivity, and utilize this relationship to define specific areas on the EM pseudosections which may represent elevated TDS content The limiting factor in determining a <u>site</u>-<u>specific</u> relationship between the TDS concentration and the pore water conductivity is the accurate characterization of the alluvial and bedrock materials in terms of their physical properties

The complex interactions which occur between the contaminant and geologic system can be more clearly understood if the potential migration pathways are located and characterized The EM method has the potential to rapidly and effectively map the shallow bedrock surface and define paleochannels which are preferential to the shallow flow of groundwater

1 0 INTRODUCTION

An electromagnetic (EM) survey was performed downgradient of two suspected source areas in an effort to determine the primary source(s) of a high total dissolved solids (TDS) plume (Figure 1) Evaluation of groundwater quality downgradient of the Landfill and Solar Evaporation Ponds has determined that both operable units are sources of TDS Concentrations of TDS in groundwater samples from the period 1986-1990 downgradient of the Landfill and Solar Evaporation Ponds ranged from 300 to 7,000 milligrams per liter (mg/l) (EG&G, 1989). The purpose of this investigation was to evaluate the effectiveness of the EM method for lateral delineation of highly concentrated TDS plumes at the Rocky Flats Plant Such an investigation had not been completed prior to this survey Therefore, an intensive review of geologic, hydrologic, and water quality data was undertaken prior to the EM data acquisition and interpretation phases

1 1 Project Goals

The Rocky Flats EM survey attempted to map the lateral extent of TDS plume(s) and define the most probable source area(s) of the plume(s) Rocky Flats Plant literature sources (Annual Ground Water Monitoring Reports, Landfill Closure Plan, Ground Water Assessment Plan) were extensively researched with emphasis on geologic, hydrologic, and water quality data which provided project geophysicists with a general understanding of the most probable contaminant source areas and potential shallow subsurface contaminant migration routes

Section 2 of this report focuses on the aquifer properties of the alluvium and bedrock materials and the surface water drainage patterns downgradient of the Landfill and Solar Evaporation Ponds Section 3 describes the correlation between the EM data and the hydrogeologic setting and establishes a relationship between the EM measured conductivity and the TDS plume(s)

2 0 GEOLOGY

The predominant lithologies at the Rocky Flats Plant include unconsolidated alluvium and colluvium, and consolidated siltstone, claystone, and sandstone The alluvial material has been classified into three distinct units as follows

Rocky Flats Alluvium

Valley Fill Alluvium

Colluvium

Source· Rockwell, 1987

The Rocky Flats Alluvium comprises the surficial material over a large area of the Rocky Flats Plant The Rocky Flats Alluvium is a poorly sorted deposit consisting of cobbles, gravel, and sand with a clay matrix It's thickness varies from 75 ft near the West Spray Field to 0 ft where the upper Cretaceous bedrock outcrops at the surface (Rockwell, 1987)

The Valley Fill alluvium and colluvium are present in and adjacent to the stream channels and valleys at the Rocky Flats Plant The Valley Fill alluvium consists of reworked and redeposited Rocky Flats alluvium and upper Cretaceous bedrock The colluvium consists of predominantly clay size particles with varying amounts of sand and gravel (Rockwell, 1987)

The uppermost bedrock underlying the Rocky Flats Plant is upper Cretaceous in age and consists primarily of weathered and unweathered claystone with interbedded fine-grained siltstone and sandstone lenses

2 1 Surface Water (Alluvial) Hydrology

North Walnut Creek, South Walnut Creek, and the unnamed drainage emanating from the Landfill (hereafter referred to as the Landfill drainage) are the three most prominent drainages within the EM survey boundaries The three drainages converge east of the water treatment pond and continue eastward towards Great Western Reservoir (Figure 1) Precipitation and snowmelt are the primary surface and shallow groundwater recharge mechanisms at the Rocky Flats Plant (Hurr, 1976)

The Landfill drainage emanates from the Landfill and travels eastward for approximately 4500 ft where it joins North and South Walnut Creeks The Valley Fill alluvium in the Landfill drainage is 6 to 10 ft thick and composed of gravels and cobbles with varying amounts of fine grained sediments (Rockwell, 1987) There is one retention pond near the termination of the landfill drainage (Figure 1) The mean hydraulic conductivity of the Valley Fill alluvium in the Landfill drainage is unknown at the present time due to a lack of aquifer tests In addition, the valley fill alluvium in the Landfill drainage is dry during some times of the year Therefore, the rate of contaminant migration cannot be accurately estimated

The Solar Evaporation Ponds drainage area encompasses North and South Walnut Creeks The South Walnut Creek drainage consists of colluvial material, and several outcrops of Cretaceous bedrock occur at the surface There are five retention ponds located in South Walnut Creek (Rockwell, 1987) The mean hydraulic conductivity of the colluvial materials from drawdown-recovery and slug tests is 98 ft/yr, although there is a large variability in test data (Rockwell, 1987)

The North Walnut Creek drainage is composed primarily of Valley Fill alluvium and terminates at the water treatment pond There are four retention ponds located in North Walnut Creek (Rockwell, 1987). The North Walnut Creek Valley Fill alluvium has a mean hydraulic conductivity of 1 5 ft/yr, which is an order of magnitude lower than measured hydraulic conductivity values for alluvial material at other areas of the Rocky Flats Plant (Rockwell, 1989) This hydraulic conductivity may be due in part to the increased clay content of the Valley Fill alluvium (Rockwell, 1987)

2 2 Groundwater (Bedrock) Hydrology

Weathered and unweathered claystone of upper Cretaceous age is the most common lithology immediately underlying the alluvial material (Rockwell, 1987) Within the claystone there are interbedded lenses of fine-to-medium-grained sandstone and siltstone

Table I lists the estimated hydraulic conductivity values of the bedrock lithologies near the Solar Evaporation Ponds

TABLE I

Solar Evaporation Ponds Hydraulic Conductivity Data

Lithology	Hydraulic Conductivity (geometric mean)
Sandstone	0 54 ft/yr
Siltstone	0 70 ft/yr
Claystone	0.35 ft/yr
Weathered Claystone	0 40 ft/yr

Source 1989 Annual RCRA Ground-Water Monitoring Report for Regulated Units at Rocky Flats Plant (packer test data)

The Solar Ponds bedrock hydraulic conductivity data does not seem to be in agreement with the accepted theory that coarse grained sediments can possess hydraulic conductivities several orders of magnitude greater than fine grained sediments However, slug test data from a Cretaceous sandstone unit in well 34-86 exhibits a hydraulic conductivity of 1,035 ft/yr, which is three orders of magnitude greater than the packer test result for the Cretaceous Solar Ponds sandstone (Rockwell, 1987)

2 3 Water Quality

Historical water quality data from the Rocky Flats alluvium, Valley Fill alluvium, colluvium, and bedrock materials indicate the presence of high concentration TDS plumes emanating from the Landfill and Solar Evaporation Ponds drainages The water bearing units at the Rocky Flats Plant consist of the various alluvial material and the upper Cretaceous bedrock sandstones and weathered claystones The alluvial material is characterized by high hydraulic conductivities relative to the unweathered claystones and other bedrock constituents (EG&G, 1989) The hydraulic conductivity and lithologic data suggest that high concentration TDS plumes travel along the alluvial/bedrock interface However, where the claystone bedrock is weathered or a subcropping sandstone or siltstone is encountered as bedrock and there is a downward gradient , the possibility of vertical contaminant migration exists (EG&G, 1989)

Additional factors which influence the water quality downgradient of the Solar Ponds area are the retention ponds located in North and South Walnut Creeks The retention ponds were constructed to limit the release of poor quality water via spills, etc (Rockwell, 1989) Surface water contamination and subsequent groundwater contaminant migration is thus affected by the holding time at each retention pond

3 0 ELECTROMAGNETIC SURVEY

3 1 EM Methodology

The EM terrain conductivity meters designed by Geonics, Ltd are based on the inductive coupling of relatively high frequency (tens of kilohertz (kHz))electromagnetic waves into the subsurface The transmitter coil emits an alternating current which creates a time-varying magnetic field and associated eddy currents in the subsurface The eddy currents generate a secondary magnetic field, which is sensed, together with the primary field, by the receiving coil (McNeil, 1980) The measured secondary magnetic field is primarily a function of the instrument frequency, transmitter/receiver separation and the conductivity of the subsurface The Geonics, Ltd EM terrain conductivity instruments are calibrated to read the conductivity of the subsurface in units of millimhos per meter (mmhos/m)

The conductivity value measured by an EM instrument depends on the combined effects of the number of soil and/or rock layers, moisture content, their thicknesses, depth(s), and the inherent conductivities of the materials. The quantity actually measured is an apparent conductivity of the earth volume between the ground surface and an effective penetration depth which is defined as the depth at which variations in conductivity no longer have a significant effect on the measurement The exploration depth is related to the spacing between the transmitter and receiver coils of the instrument, and is approximately

1 5 x coil separation (vertical dipole mode)

75 x coil separation (horizontal dipole model)

The coil separations of the EM 31 and EM 38 are approximately 12 ft and 3 ft, respectively Vertical investigation (or depth sounding) can be accomplished by multiple measurements about a point with varying coil separations Horizontal (lateral) profiling is performed by acquiring measurements along a traverse with a fixed coil separation

Two components of the EM field can be measured The quadrature-phase component is most indicative of bulk subsurface conductivity and the in-phase component most readily characterizes the presence of buried conductors In the past, electromagnetic surveys were primarily used in mineral exploration to locate faults, dikes and other linear structures EM surveys are now being utilized to locate buried pipes and cables as well as buried metallic waste (such as 55-gallon drums). Conductivity surveys are appropriate site characterization tools to

- Detect and map contaminant plumes if the conductivity contrast between the naturally occurring material and contamination is significant,
- Estimate the depth, thickness and conductivity of subsurface layers, depth to the water table, or lithologic composition of a layer,
- Determine locations for drilling to intercept contamination or to investigate aquifer properties,
- Compare chemical and geohydrologic data at a site, and
- Detect ferrous and non-ferrous metal objects that may be related to disposal activities

3 1 1 EM Modeling

Existing TDS and specific conductance data from 29 monitor wells located in the Landfill and Solar Ponds drainages were analyzed to define a relationship between TDS and specific conductance The largest influence on the EM measured conductivity is the conductivity (or specific conductance) of the groundwater Figure 2 exhibits the relationship between the groundwater conductivity (in mmhos/m) and the TDS content of the groundwater The relationship was derived to assist project geophysicists with the analysis of the EM data

A general model which allowed the acquired EM data to be interpreted in terms of the groundwater conductivity was implemented by project geophysicists (Appendix A) The relationship is theoretical in nature and will not be presented as part of this report, although project geophysicists can present in detail the relationship upon EG&G's request

Briefly, the model accounts for the interrelationships between the EM measured conductivity, groundwater conductivity, TDS content, volumetric water content, and mineralogical matrix materials There are two constants in the equation which must be determined from a simple lab measurement The lab measurement consists of

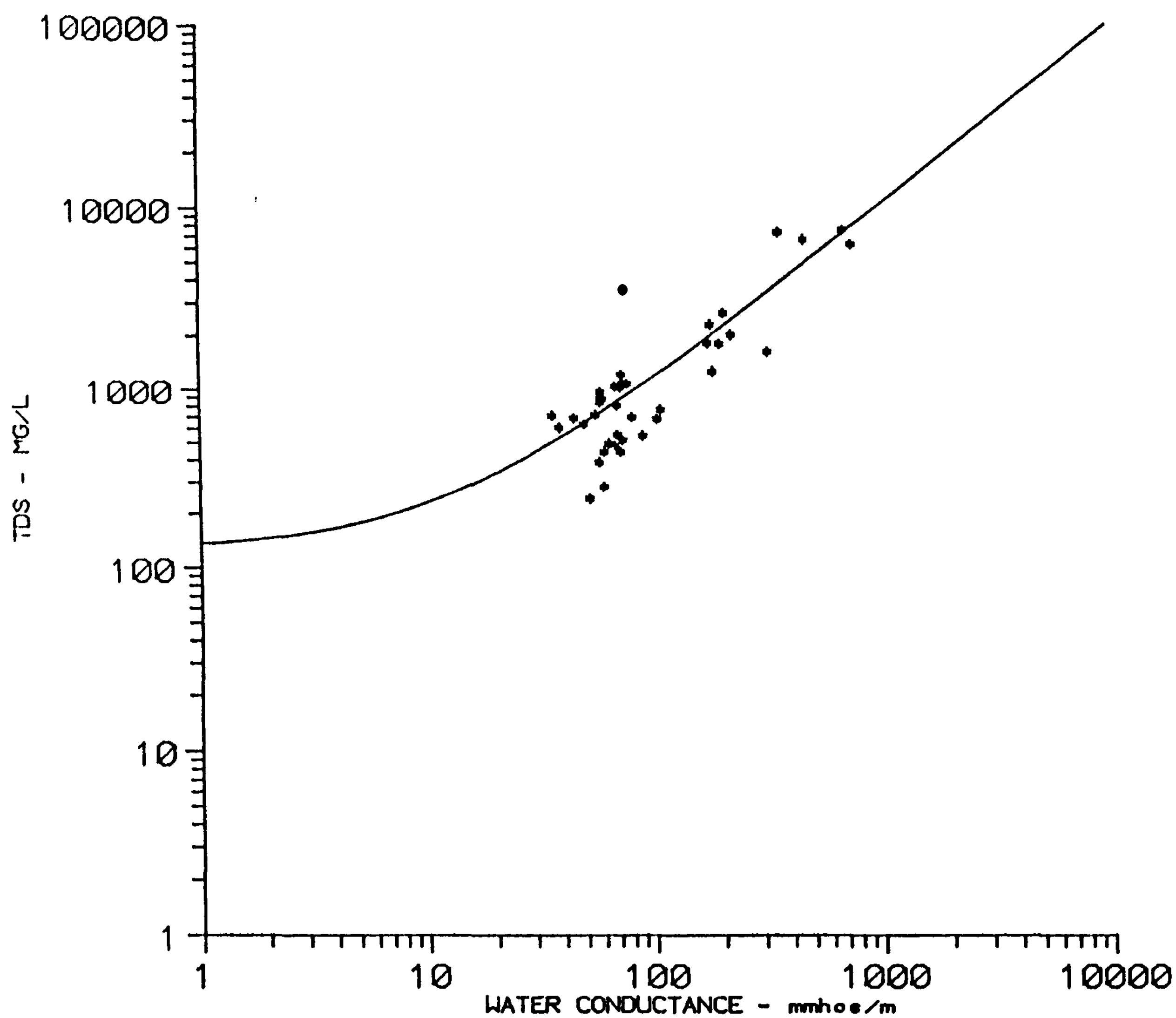

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Figure 2
TDS Concentration vs. Water Conductivity

measuring the conductivity of an alluvial sample dry and at field capacity (water saturated) We suggest collecting alluvial lithologic samples near several monitor wells in the Landfill and Solar Ponds drainages and have them analyzed at a laboratory for the following

grain size distribution,

clay mineralogy,

dry conductivity and

saturated conductivity

This data can be utilized in the aforementioned relationship to provide an accurate, site-specific groundwater conductivity.

3 2 Data Acquisition

The Geonics EM 31 and EM 38 terrain conductivity meters were used to acquire data on 16 profiles in the Landfill and Solar Ponds drainages (Figure 1) The EM 31 was used in the horizontal dipole mode and the EM 38 was used in the horizontal and vertical dipole mode Quadrature and in-phase data were acquired,and digitally recorded with a data logger The length of the EM profile lines varied between 100 and 1,200 ft, and special care was exercised to avoid and/or minimize the effects of cultural interference caused by overhead and buried power lines, and steel-cased monitor wells.

The EM 31 was used in a reconnaissance mode with a 5 ft station spacing to determine the applicability of the EM terrain conductivity method to define a high TDS plume in a complex geologic environment The EM 38 was utilized to improve the vertical and lateral resolution of the complex geologic system, thus a 2 ft station spacing was used

3 2 1 Water Sampling

EBASCO field personnel measured the specific conductance of 29 water samples acquired in monitor wells adjacent to the EM survey lines and located in the Landfill and Solar Ponds drainages The specific conductance measurements were acquired within one week of the EM survey to provide information on the conductivity of the pore water, which aided in the interpretation of the EM data

3 2 2 Surveyıng

A total statıon surveyıng ınstrument was used to survey EM profile lınes 1 through 16 The startıng and endıng profile lıne statıons were converted to the state planar coordınate system and plotted on a topographıc map of the Rocky Flats Plant (Fıgure 1)

3 3 Data Processıng

The EM 31 and EM 38 data were processed wıth Geonıcs Ltd DAT31 (versıon 2 08) and DAT 38 (versıon 2 04), respectıvely The data processıng sequence consısted of the followıng

- lıne orıentatıon (all profiles are presented as ıncreasıng statıons ın a north dırectıon)
- organızatıon of data ınto pseudosectıons
- pseudosectıon plottıng

Project geophysıcısts generated pseudosectıons to exhıbıt the changes ın subsurface conductıvıty versus depth The pseudosectıons were generated by usıng the maxımum depth of penetratıon for the EM 31 and 38 ınstruments along the profile lıne as follows·

Instrument	Configuratıon	Maxımum Depth of Penetratıon
EM38	horızontal dıpole mode	~ 2 5 ft
EM 38	vertıcal dıpole mode	~ 5 0 ft
EM 31	horızontal dıpole mode	~ 9 0 ft

The pseudosectıons were contoured wıth the Radıan Corporatıon's CPS/PC contour plottıng system Each pseudosectıon ıs a geoelectrıc sectıon whıch represents the spatıal change of conductıvıty along the EM profile

3 4 Data Analysis and Interpretation

If the alluvial sediments at the Rocky Flats Plant consisted of one dominant lithologic member (i e , sand, clay, or gravel), an increase in the measured EM terrain conductivity would indicate an increase in the conductivity of the groundwater The increase in the conductivity of the groundwater could be interpreted as an elevated TDS concentration, or as a result of natural minerals occurring in the water (EG&G, 1989) However, the alluvial material at the Rocky Flats Plant is a complex composition of varying amounts of gravel, sand, silt, clay, and organic material Thus, due to the complex geologic environment care was exercised when interpreting the EM data in terms of elevated TDS content

Geophysicists have estimated a background conductivity range for the alluvial sediments at the Rocky Flats Plant based the EM modeling and field investigation and a previous EM investigation (Chen and Associates, 1987) The primary factors which dominate the subsurface conductivity are

- the porosity of the material,
- amount of water in the pore space,
- conductivity of the pore water,
- mineralogical type

The background conductivity range for alluvial sediments is interpreted to be approximately 20 to 80 mmhos/m Figures 3, 4, 5, 6, and 7 are selected pseudosections of EM profile lines in the Landfill and Solar Ponds drainages Conductivities which are higher than 80 mmhos/m are interpreted to be areas where there is potential for elevated TDS levels However, conductivities above 80 mmhos/m may also be areas where there is highly conductive clay present in large quantities The data exhibited in Table II illustrates the wide range of conductivities that can be expected due to changes in moisture content, grain size, and mineralogical clay type:

TABLE II

Conductivity Variance with Moisture and Clay Content

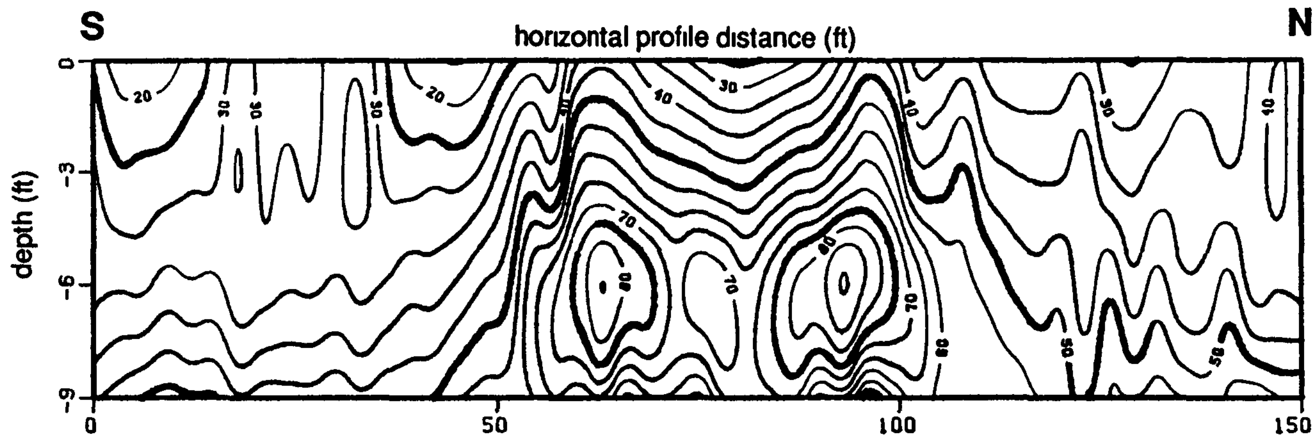
Moisture (%)	Conductivity (mmhos/m)	Clastics (%)	Clay (%)	Clay Type(s)
42	16 0	21	79	100% kaolinite
46	1.2	42	58	100% kaolinite
25	1 0	5	95	100% kaolinite
21	65.0	66	34	100% montmorillonite
32	169 0	39	61	60% montmorillonite 40% kaolinite
25	269 0	15	85	90% montmorrillonite 10% kaolinite

Source Walker, et al 1973

3 4 1 Solar Evaporation Ponds Drainage

The Solar Evaporation Ponds drainage pseudosections (Figures 3 and 4) are characterized by specific subsurface regions which are above the background value of 80 mmhos/m Figure 3 represents the Line 10 EM pseudosection There is a distinct change in subsurface conductivity between horizontal stations 50 and 100 at 6 ft in depth where the conductivity is greater than 80 mmhos/m The increase in conductivity may be caused by by an increase in the conductivity of the groundwater (elevated TDS), however, it may also reflect an area where the lithology is dominantly mineralogical clay Monitor well B208289 is located near station 70, and the lithology consists of weathered claystone and silty claystone between the depths of 1 9 and 9 ft The upper 1 9 ft is described as clayey topsoil

Line 10 Pseudosection
Solar Ponds Drainage



contour interval = 5 mmhos/m

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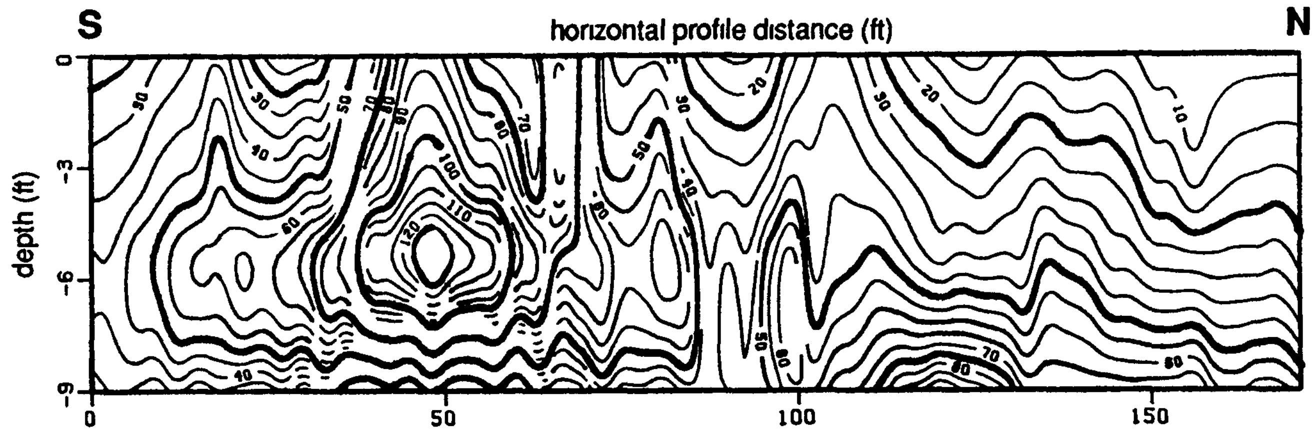
Figure 3
EM Pseudosection

Line 14 Pseudosection
Solar Ponds Drainage



contour interval = 5 mmhos/m

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Figure 4
EM Pseudosection

The Line 14 pseudosection is exhibited in Figure 4. The conductivity anomaly near station 50 between the depth of 2 and 7 ft represents an area which is most likely related to elevated TDS content in the groundwater The highest conductivity recorded during the Rocky Flats EM survey (128 mmhos/m) occurred at station 50 at an approximate depth of 6 ft The conductivity decreases near station 50 from 6 ft to 9 ft , making it improbable that the conductivity anomaly is due to the effect of the deeper claystone bedrock The alluvial lithology in monitor well 37-86, located approximately 50 ft west of the EM profile line, is described as a silty and sandy clay from the surface to a depth of 9 ft

3 4 2 Landfill Drainage

The Landfill drainage pseudosections are exhibited in Figures 5, 6, and 7 EM profile lines 2 and 6 (Figures 5 and 7) represent areas where there is no evidence that suggests an elevated TDS content. The conductivity of the alluvial material ranges from approximately 10 to 50 mmhos/m, which is in agreement with previous background EM measured conductivities for alluvial material (Chen and Associates EM data, 1987) However, the relationship between the EM measured conductivity and the groundwater conductivity in some areas of the Landfill drainage is uncertain. EM profile Line 4 (Figure 6) is located between monitor wells 42-87 and 6-86. Monitor well 6-86 exhibited a TDS value of 4542 mg/l in May, 1988 Conversely, monitor well 42-87 (upgradient of monitor well 6-86) exhibited 355 mg/l TDS in February, 1988 Several conclusions may be inferred from this relationship

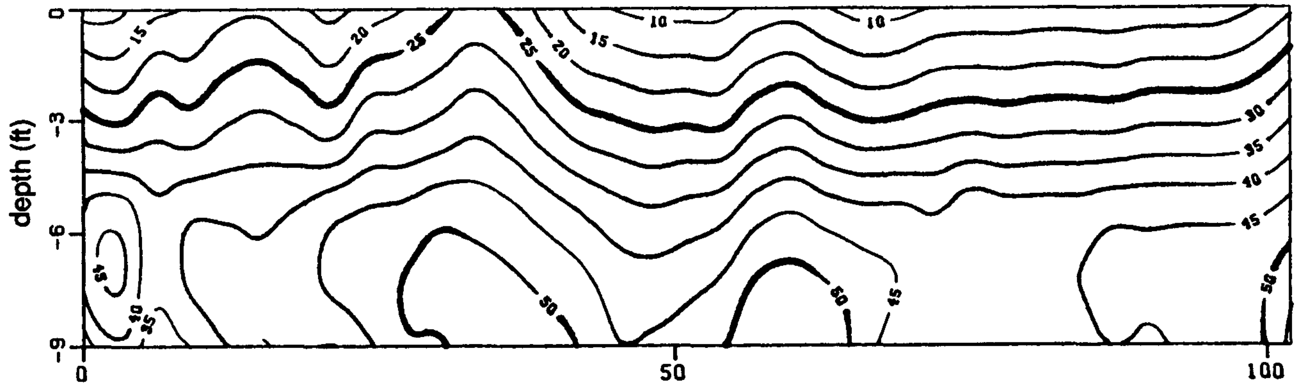
#1 -monitor well 42-87 was not completed properly, or

#2 -the rate of contaminant migration in the Landfill drainage is extremely high, or

#3 -an unknown paleochannel(s) exists which is laterally offset from the surface water drainage pattern in the Landfill drainage

The EM survey data tends to support conclusion #3 For example, pseudosection 4 (Figure 6) exhibits an area of lower conductivity between stations 30 and 60 which correlates with the present surface water drainage The conductivity anomaly between stations 60 and 90 from a depth of 2 to 9 ft may indicate a shallow paleochannel that is preferential for shallow

Line 2 Pseudosection
Landfill Drainage



contour interval = 5 mmhos/m

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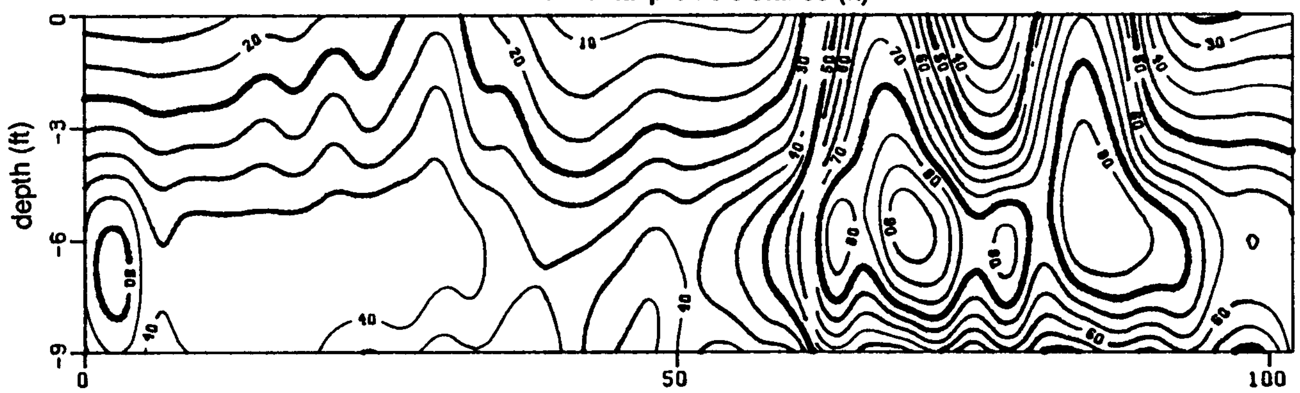
Figure 5
EM Pseudosection

Line 4 Pseudosection
Landfill Drainage



contour interval = 5 mmhos/m

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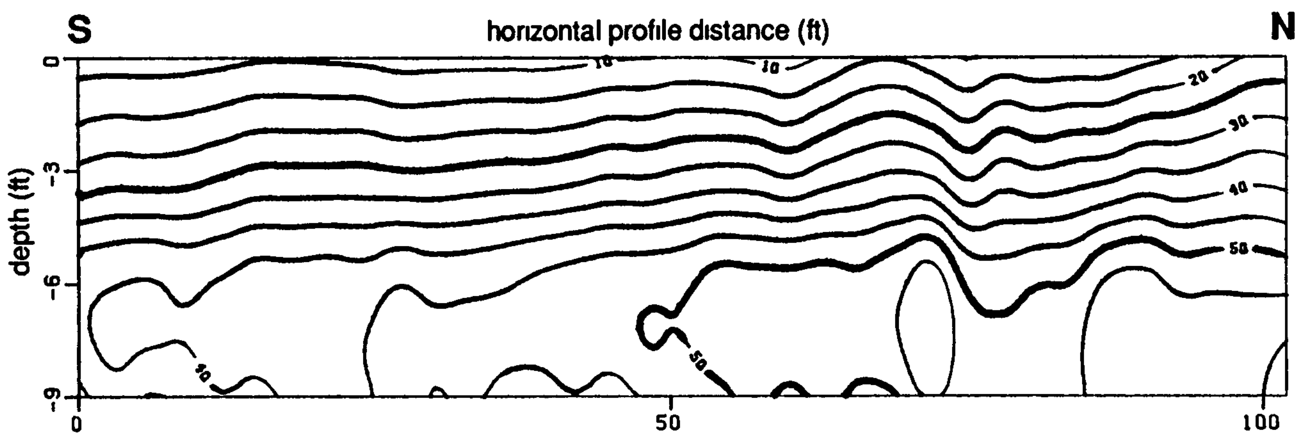
Figure 6
EM Pseudosection

Line 6 Pseudosection
Landfill Drainage



contour interval = 5 mmhos/m

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Figure 7
EM Pseudosection

groundwater flow. The conductivity of 90 mmhos/m near station 70 at an approximate depth of 6 ft may indicate elevated TDS groundwater flowing on the lower conductivity weathered bedrock paleochannel at a depth of 9 ft

4 0 CONCLUSIONS

The Solar Evaporation Ponds drainage EM pseudosections exhibited isolated subsurface areas of high conductivity which are most likely related to elevated TDS content of the groundwater

The Landfill drainage EM psedosections are representative of subsurface areas which consist of background conductivities between 20 and 80 mmhos/m The pseudosection for Line 4 exhibits an isolated subsurface area which may be the expression of a TDS plume traveling on the alluvial/bedrock contact However, the increase in conductivity on Line 4 may also represent an area that is saturated with conductive clay.

The shallow geologic and hydrologic system present at the Rocky Flats Plant is complex and additional work is necessary to characterize the distribution of lithologic grain sizes, clay mineralogy, and aquifer properties of the alluvial and bedrock materials The upcoming Phase II Geologic Characterization will provide relevant lithologic and hydrologic data which can be utilized to further understand the EM data in terms of delineating high TDS plumes

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APPENDIX A

The detection of subsurface contamination with the use of electrical geophysical methods is a relatively new frontier   Currently, three geophysical methods have exhibited potential to detect organic and inorganic contamination in the subsurface

Ground Penetrating Radar (GPR)
Complex Resistivity
Electromagnetic Induction (EM)

Ground penetrating radar can map some hydrocarbon contaminants, however, the presence of conductive clay minerals can restrict the depth penetration of the radar pulse (Olhoeft, 1986)   Resistivity methods (including complex resistivity) have proved effective in detecting some organic and inorganic contamination, but the method is time consuming in both the data acquisition and interpretation phases   The EM induction technique is a cost effective alternative to the resistivity method   The EM terrain conductivity meters pioneered by Geonics Ltd are more portable than resistivity or GPR systems and less time consuming in the data acquisition phase   EM data can be used to effectively map inorganic and organic contamination if the contrast between the contamination and the geologic system is large enough. Therefore, the Rocky Flats Task 5 geophysical program was performed with the Geonics Ltd EM 31 and EM 38 instruments in an attempt to determine the effectiveness of the EM technique in detecting a high concentration TDS plume.

A previous EM investigation was performed by Chen and Associates at the Rocky Flats Plant in 1987   The EM survey was completed in the Operable Unit 2 (OU2) area to characterize the Solid Waste Management Units (SWMU)   The EM data exhibits background conductivities between approximately 20 and 60 mmhos/m for the alluvial material   This background range of alluvial conductivities was used to construct a starting model for the Task 5 EM survey   Additional conductivity information was acquired from data obtained in the recent borehole geophysics program with the Geonics Ltd EM 39 borehole induction probe   The EM 39 data from several boreholes was used to estimate the conductivity of the bedrock materials   Conductivity values between 100 and 200 mmhos/m represent the range of conductivities which characterize the claystone bedrock used in the Task 5 EM model

Two EM models were generated for the Task 5 EM project The first model consisted of a simple three-layer geologic section as described in Figure A-1 The EM instrument response was calculated for a perpendicular traverse over the high TDS plume   The results of the

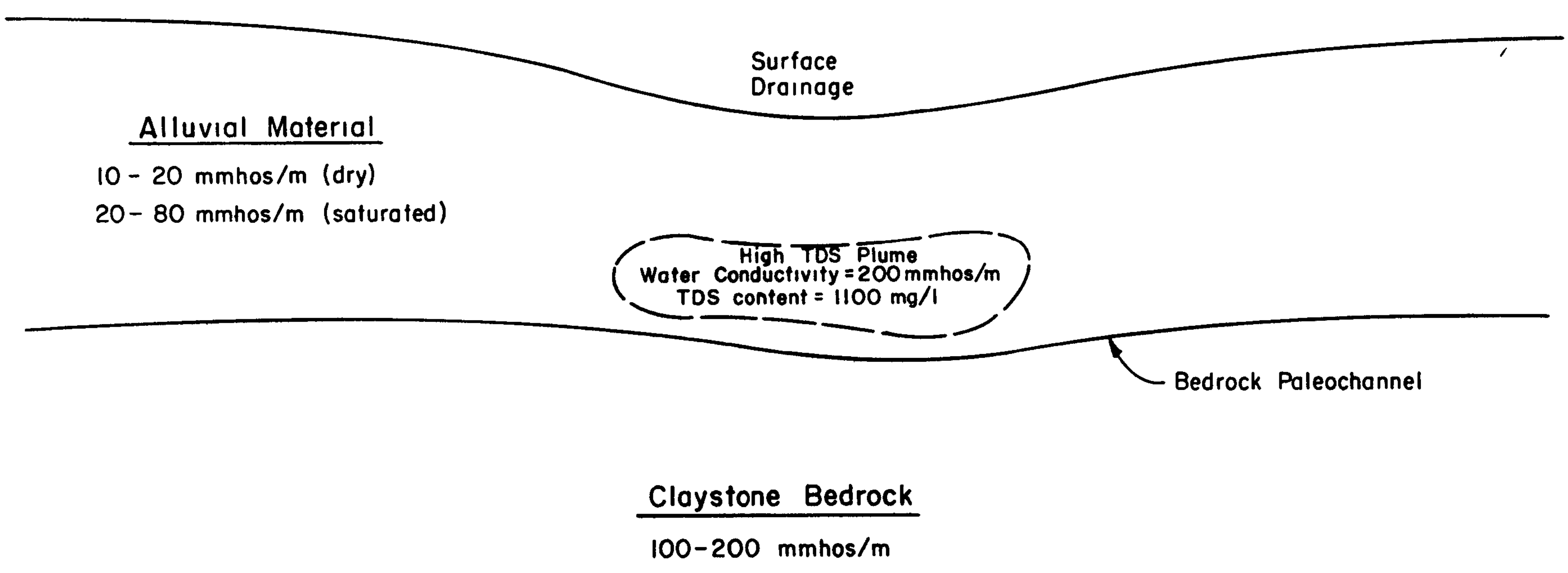

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Figure A-1
Plume Model

model indicate a high probability of detecting a TDS plume that is characterized by a ratio of plume conductivity to alluvial conductivity of approximately 2 1 However, the model is idealistic, since it assumes a homogeneous, layered geologic system with definitive boundaries Historic alluvial and bedrock lithologic data acquired at the Rocky Flats Plant suggest a much more complex geologic system Therefore, it was necessary to construct a second geologic model which takes into account the following parameters

- petrophysical properties of the alluvial and bedrock materials (mineralogic composition, surface area, cation exchange capacity),

- porosity of the material and amount of water in the pore system,

- pore water conductivity

A model is suggested in which the conductivity of the groundwater (i e pore water conductivity) can be solved for given the following information

- EM measured conductivity,

- volumetric water content of the soil,

- two lithologic constants

The lithologic constants can be derived by a simple lab procedure in which the conductivity of the lithologic sample is measured dry and at field capacity (saturated).

Rhoades, Raats, and Prather (1976) proposed the following equation to determine the bulk soil conductivity O_B

$$O_B = O_W \, O \, (a \, O + b) + O_S$$

where O = volumetric water content

O_W = pore water conductivity

a,b = lithologic constants for soil type and composition

O_S = surface conductance of lithologic material(s)

Table I exhibits the grain size distribution, values for the constants a and b, and the surface conductance of the lithologic samples the investigators acquired by measuring the conductivity of the sample dry and at various water saturations

TABLE A-I

SOIL TYPE	SAND %	SILT %	CLAY %	Os	a	b
Pachappa	49	37.8	11 2	18	1.382	- 093
Indio	42 2	51 6	6.2	25	1.287	- 116
Waukena	41 3	39 0	19 7	40	1 403	- 064
Domino	29 3	41 4	29 3	45	2 134	- 245

These data were used as input model parameters to approximate the lithologic properties at the Rocky Flats Plant The target TDS concentration for the Rocky Flats Plant has been set at 400 mg/l (EG&G, 1989) 400 mg/l TDS corresponds to a pore water conductivity of approximately 30 mmhos/m based on the relationship proposed by Ebasco in Section 3.1 1 Therefore, the model pore water conductivity (Ow) was varied between 30 mmhos/m (background TDS) and 500 mmhos/m (significantly elevated TDS) for the different lithologies in Table A-I.

The results of the second Task 5 EM model were more accurate in approximating the proposed TDS/pore water conductivity relationship for the Rocky Flats Plant However, the model can be made more accurate if the lithologic materials at the Rocky Flats Plant are characterized with a similar investigative approach to that of Rhoades, Raats, and Prather

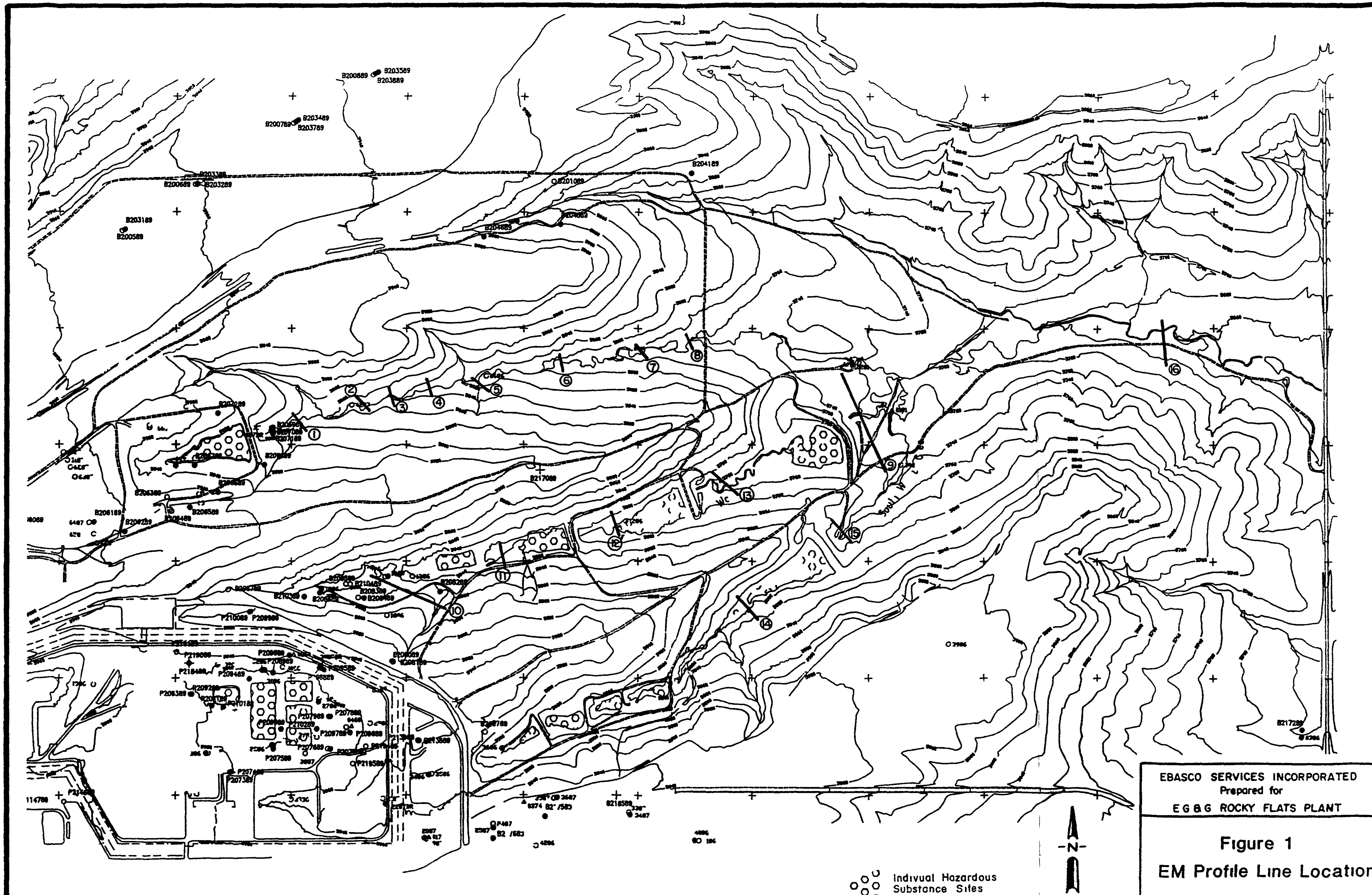

Figure 1
EM Profile Line Location